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LIMITING BRIGHTNESSES OF A SPARK DISCHARGE CHANNEL.(U)
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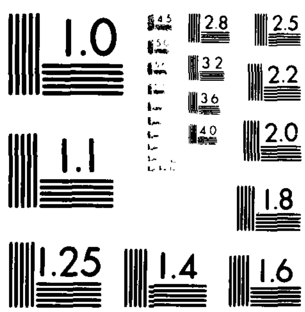
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# FOREIGN TECHNOLOGY DIVISION

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LIMITING BRIGHTNESSES OF A SPARK DISCHARGE CHANNEL

by

M. P. Vanyukov, A. A. Mak and A. I. Sadykova





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# EDITED TRANSLATION

FTD-ID(RS)T-1509-80 6 January 1981

MICROFICHE NR: FTD-81-C-000077

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English pages: 5

Source: Doklady Akademii Nauk SSSR, Vol. 135, Nr. 3, 1960, pp. 557-559

Country of origin: USSR
Translated by: SSgt John S. Fisher.
Requester: FTD/TQTD
Approved for public release; distribution unlimited.





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## U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

| Block | Italic | Transliteration | Block | Italic | Transliteration |
|---|---|---|---|---|---|
| А а | *А а* | A, a | Р р | *Р р* | R, r |
| Б б | *Б б* | B, b | С с | *С с* | S, s |
| В в | *В в* | V, v | Т т | *Т т* | T, t |
| Г г | *Г г* | G, g | У у | *У у* | U, u |
| Д д | *Д д* | D, d | Ф ф | *Ф ф* | F, f |
| Е е | *Е е* | Ye, ye; E, e* | Х х | *Х х* | Kh, kh |
| Ж ж | *Ж ж* | Zh, zh | Ц ц | *Ц ц* | Ts, ts |
| З з | *З з* | Z, z | Ч ч | *Ч ч* | Ch, ch |
| И и | *И и* | I, i | Ш ш | *Ш ш* | Sh, sh |
| Й й | *Й й* | Y, y | Щ щ | *Щ щ* | Shch, shch |
| К к | *К к* | K, k | Ъ ъ | *Ъ ъ* | " |
| Л л | *Л л* | L, l | Ы ы | *Ы ы* | Y, y |
| М м | *М м* | M, m | Ь ь | *Ь ь* | ' |
| Н н | *Н н* | N, n | Э э | *Э э* | E, e |
| О о | *О о* | O, o | Ю ю | *Ю ю* | Yu, yu |
| П п | *П п* | P, p | Я я | *Я я* | Ya, ya |

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

## RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

| Russian | English | Russian | English | Russian | English |
|---|---|---|---|---|---|
| sin | sin | sh | sinh | arc sh | $\sinh^{-1}$ |
| cos | cos | ch | cosh | arc ch | $\cosh^{-1}$ |
| tg | tan | th | tanh | arc th | $\tanh^{-1}$ |
| ctg | cot | cth | coth | arc cth | $\coth^{-1}$ |
| sec | sec | sch | sech | arc sch | $\operatorname{sech}^{-1}$ |
| cosec | csc | csch | csch | arc csch | $\operatorname{csch}^{-1}$ |

| Russian | English |
|---|---|
| rot | curl |
| lg | log |

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# LIMITING BRIGHTNESSES OF A SPARK DISCHARGE CHANNEL

M. P. Vanyukov, A. A. Makm and A. I. Sadykova

(Presented by Academician A. A. Lebedev 25/5/1960)

A number of works (1-3) are dedicated to investigating limiting brightnesses of a spark discharge channel; however, only in heavy inert gases was a saturation of brightness able to be observed in a wide area of the spectrum (2300-900 Å). The saturation of brightness occurred only in the long wave part of the spectrum in light gases with the used rates of the current's growth.

An investigation of the limiting brightnesses of a spark discharge channel in argon, nitrogen, air, and helium upon extremely high rates of current growth ($U/L \simeq 10^{12}$ A/s) was the goal of this work. The discharge was accomplished in a high pressure chamber having a window for the outlet of light*. The discharge circuit was characterized by the following parameters**. C = 0.1-1.0 μF, L = 4-8 nH, U = 2-10 kV, the length of the spark gap was ~ 1.5 mm.

Measurements of the brightness were accomplished from the emission of a continuous background in the spectral range of 400-9000 Å and

*The chamber's design was developed by B. R. Muratov.

** Low-induction capacitors similar in design to those described in (4) were used in this work.

in points of the spectrum corresponding to the maxima of strongly broadened spectral lines: He II 4686 Å, Ar II 4348 Å, Ar II 4608 Å, N III 4097 Å, N II 5045 Å.

Limiting brightnesses were attained in all the investigated gases thanks to the extremely high current growth rates. The values of the channel's limiting brightness temperatures and the discharge conditions corresponding to them are presented in Table 1.

Table 1.

| (1) Газ | (11) Режим | | | $T_{ярк.}$, K (9) | B, Мсб (10) |
|---|---|---|---|---|---|
| | P, ат (6) | U/L, $10^{12}$ а/сек (7) | C, мф (8) | | |
| Гелий (2) | 31 | 1,02 | 0,2 | 70 000 | 37 |
| Азот (3) | 3 | 1,1 | 0,1 | 62 000 | 32 |
| Аргон (4) | 3 | 0,32 | 0,2 | 46 000 | 22 |
| Воздух (5) | 1 | 0,85 | 0,1 | 38 000 | 17 |

KEY: (1) Gas; (2) Helium; (3) Nitrogen; (4) Argon; (5) Air; (6) P, in at.; (7) U/L, in $10^{12}$ A/s; (8) C, in μF; (9) $T_{APK}$, in °K; (10) V, in Megastilbs; (11) Conditions.

The channel's emission was observed both from the end as well as in a direction perpendicular to the axis of the discharge. The obtained values of brightness temperature in this case coincided.

It was established that a change of the discharge circuit's capacitance value does not exert a significant influence on the channel's brighness.

It is necessary to note that the limiting brightnesses of the spark discharge's emission in helium, argon, and air measured in this work are significantly different from the results of corresponding measurements presented in (4, 5). There is a basis to assume that a significant overstating of the brightness values in (4, 5) is connected with a disregard for the spectral distribution of the discharge channel's emission.

The dependence of the discharge channel's limiting brightness temperature on the wavelength in saturation modes is presented in

Fig. 1. It is seen from the figure that the spark discharge channel's emission is close to ideal black body radiation in the saturation mode.

It was established that if the discharge mode becomes even more stringent after attaining the limiting values of brightness, then a slight reduction of the brightness is observed, which apparently is connected with the absorption of emission in the discharge channel's peripheral layers. The dependence of the channel's brightness temperature in helium on the discharge mode is presented in Fig. 2 as an example.

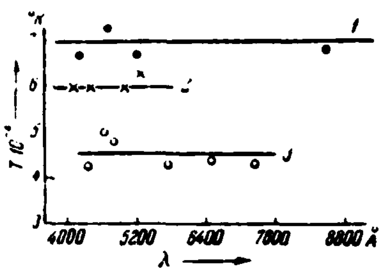

Fig. 1.

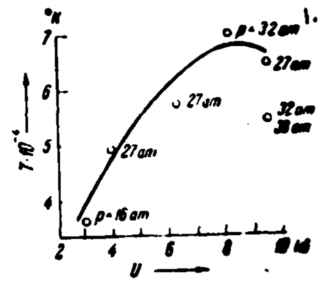

Fig. 2.

Fig. 1. 1 - Helium; 2 - Nitrogen; 3 - Argon.

Fig. 2.

KEY: (1) at.

The question about the degree of influence of the impurities on the channel's brightness in helium is very significant. Due to the high ionization potential of this gas the presence of small amounts of impurities of easily ionized gases may cause a reduction of the discharge channel's temperature in helium. Experiments conducted with helium of various degrees of purity showed that even with a maximum content of heavy impurities (~4%) a cooling of the channel is not observed in helium.

The conducted investigations confirm a conclusion made in (1-3) about the fact that with a lowering of the atomic weight of a gas the spark discharge channel's limiting temperature is increased. An exception is oxygen in which the temperature is lower than in nitrogen and argon. The reason for this is not clear. In (7-9) it was

established that the temperature of the spark discharge channel in air is virtually independent of the discharge mode (within certain limits of the latter's change). Therefore, it can be assumed that attaining limiting values of brightness is caused by an attainment of the discharge channel's opacity.

If we use the conclusions of the Kramers-Unsöld theory (6) for the absorption coefficient of continuous emission and the hydrodynamic theory of a channel's expansion, then it is possible to obtain the following relationship which connects the slope of current growth in the U/L circuit, which is necessary in order to achieve the channel's opacity, with the basic parameters of discharge plasma:

$$\left(\frac{U}{L}\right)^{6/5} = c\,\frac{(kT)^{9/4}\nu^{3}}{\rho_0^{7/6} Z^{2}_{эфф}\,(e^{h\nu/kT}-1)}\,t^{-1/5},$$

where T is the plasma's temperature (it is suggested that the plasma be isothermic); $\nu$ — is the luminous vibration frequency; $\rho_0$ is the initial density of a gas; $Z_{эфф}$ is the effective ion charge; t is the time measured from the start of the discharge (it is assumed that $t < \sqrt{LC}$); c is a constant.

From the relationship presented it is possible to draw the following conclusions.

1. A condition of opacity is satisfied more easily for low frequencies. Thus, the channel's opacity is attained at first in the red area of the spectrum and then in the blue area in proportion to the increase of the current's growing rate in the discharge.

2. With the assigned parameters of a discharge circuit the channel's opacity is attained most easily in heavy gases. If we further consider that the channel's temperature falls with the increase of atomic weight, then it makes clear the strong dependence of the slope of the current necessary for attaining saturation of brightness on the atomic weight of the gas.

3. An increase of pressure makes attaining the saturation of brightness easier.

It is easy to see that theoretical regularities agree well with experimental results.

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Received
May 20, 1960

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